Space Weather Technical Forecast

Issued on Friday, 05 May 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1-R2 blackouts expected throughout with a slight chance of R3 Strong radio blackouts. G1-G2/Minor-Moderate Storm conditions expected Days 3-4 (7-8 May) with a chance of G3/Strong Storm conditions. Active electron fluence continuing, but declining.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with a M2.1 flare at 05/0801UTC from AR3296 Dki/beta, although this region is not the largest on the visible disc. In total there are six numbered regions on the visible disc, AR3293 previously exhibited a small delta spot which has since faded. The largest region on the disc is AR3297, currently classified as Eki/beta. The remaining regions are relatively small, weak and magnetically simple.
Numerous CMEs have departed from the Sun over the past 24 hours. Most of these appear far-sided. One faint full halo CME appears on the latest SOHO-Lasco-C2 imagery, analysis of this is ongoing. An earlier full halo CME appears to be associated with the M3.9 flare event from 4 May. Both of which are anticipated to have an Earth-directed component. Further analysis will be undertaken to determine if any of the other CMEs leaving the Sun have Earth-directed components.

Solar Wind / Geomagnetic Activity: The solar wind observed at L1 has been fairly steady, persisting at predominantly slightly elevated levels and peaking at 469 km/s at 05/0338 UTC. Density has been at Average to Below Average levels. Total magnetic field strength remained weak. The north-south component of the magnetic field has been weak, and predominantly negative. Phi angle was consistently negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2) throughout.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at background levels throughout. High energy electron flux (greater than 2MeV) as measured at GOES16, has remained at High levels, peaking at 6983pfu at 04/1745UTC. The 24-hour integrated fluence was at Active levels, with a gradually decreasing trend. At 05/0000 UTC 2.54e8 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected with M-class flares, and a slight chance of X-class flares. Significant flares are most likely from AR3293, AR3296 and AR3297 in the northeast.
Solar Wind / Geomagnetic Activity: At present a CME, associated with the M3.9 flare on 4 May, is expected to arrive at Earth either late on Day 3 (7 May) or early on Day 4 (8 May). A second CME, may arrive at Earth late on Day 4 (8 May), but there is currently low confidence in detail and analysis remains underway. Connection to the HSS from CH99 is possible later today, but is more likely tomorrow (6 May), with additional enhancement from a smaller, weaker coronal hole on Day 2 or 3.

Further analysis is required of the most recent CMEs, leading to a high level of uncertainty in regards to forecast geomagnetic activity.

Geomagnetic activity is expected to be Quiet (Kp 1-2) today increasing through Day 2 to Unsettled to Active (Kp 3-4). Chance of a G1/Minor (Kp 5) geomagnetic storm occurring later

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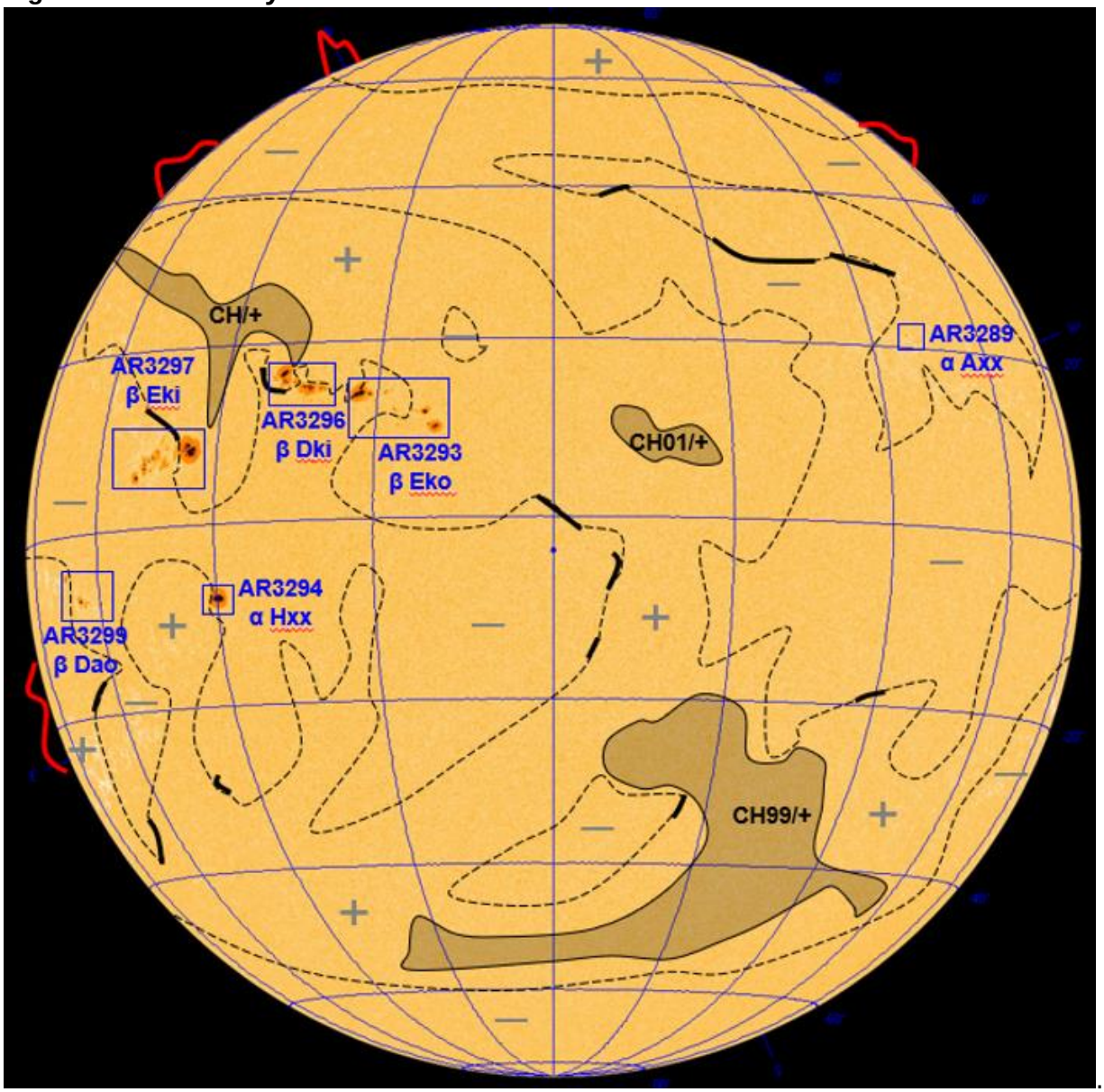
tomorrow with the arrival of the CIR ahead of the HSS from CH99. G1-G2/Minor-Moderate Storm (Kp 5-6) intervals are likely late Day 3 and into Day 4 due to the expected arrival of CMEs; also a slight chance of a G3/Strong Geomagnetic storm (Kp7) interval.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to persist at background with no solar radiation storms occurring. High energy (greater than 2MeV) electron flux is expected to continue a diurnal oscillation, mainly above the High threshold, but with slightly declining peaks, until any geomagnetic storms occur. Geomagnetic storms are possible in association with HSS arrivals, but are most likely either Day 3-4. Therefore by the end of the forecast period, Background to Moderate high energy electron flux levels are expected. The corresponding electron fluence is expected to continue above the Active threshold (1e8 integrated flux), but with a declining trend, until late Day 3 or early Day 4, thereafter falling below the Active threshold.

Figure 1. Solar Analysis Valid 05/1000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
At present a CME, associated with the M3.9 flare on 4 May, is expected to arrive at Earth either late on Day 3 (7 May) or early on Day 4 (8 May). A second CME, associated with a far-sided feature, may arrive at Earth late on Day 4 (8 May). However, analysis of this feature is still underway and there is low confidence in detail.

AR3288, which recently rotated across the western limb, appears to have released a narrow, slow-moving CME, associated with a C4.9 flare. Current analysis would suggest that this feature will not impact Earth during the period, if at all.

Further analysis is required of the most recent CMEs, leading to a high level of uncertainty in regards to forecast geomagnetic activity.

A connection to the HSS from CH99 is possible later today (5 May), but is more likely tomorrow (6 May). The connection is likely to last for the remainder of the period, waning towards the end of Day 4 (8 May). Connection to a second, smaller and weaker, HSS from CH01 on Day 2 or 3 (6-7 May). Speeds are uncertain, as CH99 was not present on the previous rotation and on this current rotation CH01 is slightly smaller than before. The combined high speed stream could reach speeds of 500-550km/s.

Connection to the HSS is yet to be observed at STEREO-A, which is approximately a day ahead of Earth. Uncertainty exists in the forecast as a result of the enhanced solar winds not yet presenting.

Geomagnetic activity is expected to be predominantly Quiet (Kp 1-2) today increasing Unsettled (Kp 3) tomorrow (6 May) and Unsettled to Active (Kp 3-4) later Day 2 into Day 3 upon arrival of the HSS from CH99. There is also a chance of a G1/Minor (Kp 5) geomagnetic storm occurring late tomorrow with the arrival of the CIR ahead of the HSS from CH99. G1-G2/Minor-Moderate Storm (Kp 5-6) intervals are likely late Day 3 and into Day 4 due to the expected arrival of CMEs. During this same period there is also a slight chance of a G3/Strong Geomagnetic storm (Kp7) interval.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	70	70
Strong	G3	No	1	1	20	20
Severe	G4	No	1	1	3	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1327	Full halo	M-Class from AR3296	NE	850 km/s	07/2300 UTC	Complex analysis. Moderate confidence in source.

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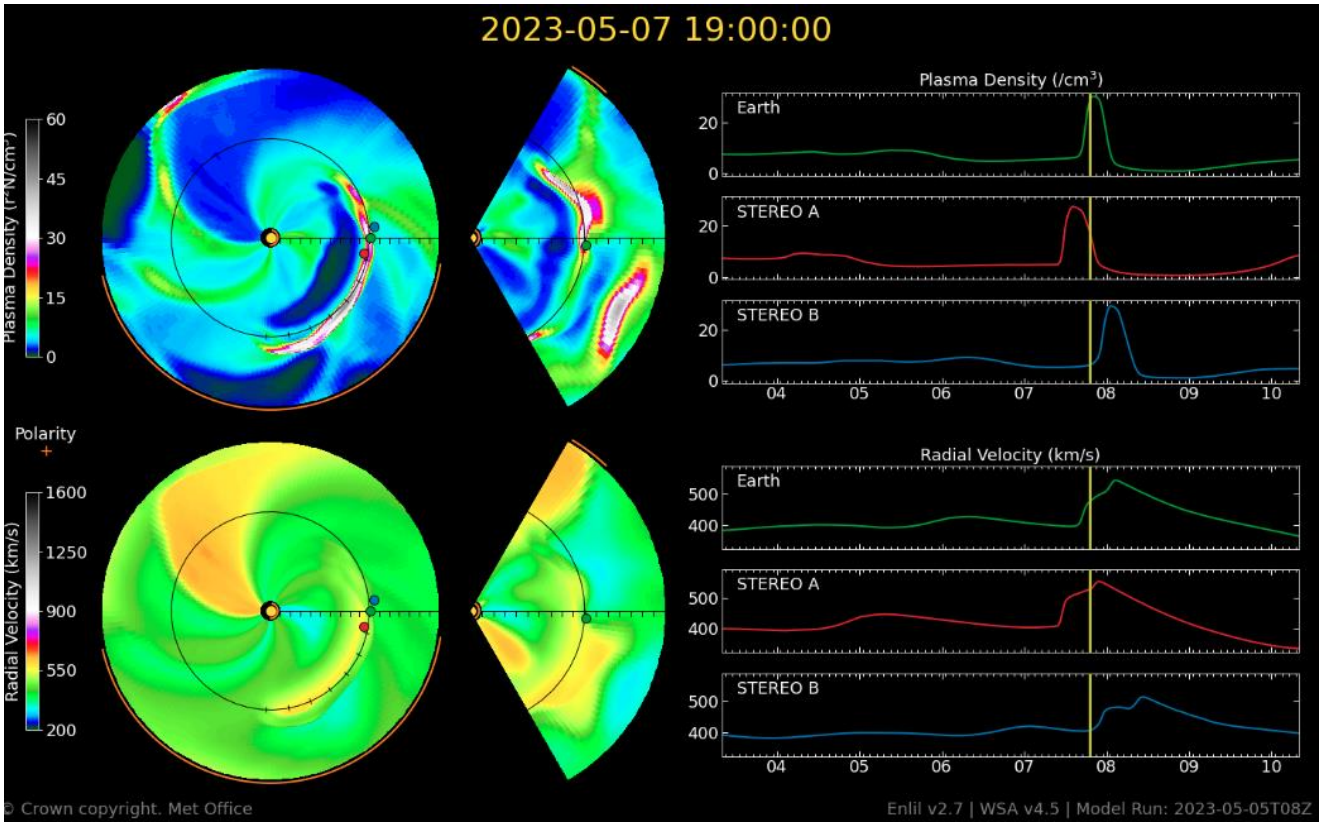
Figure 2: Latest MOSWOC Enlil showing arrival of CME on Day 3 (7 May). Note absence of 2nd halo CME as yet to be input into Enlil.



Radio Blackouts - X-Ray Flares:

There are currently six sunspot regions on the visible disc, with AR3288 having fully rotated across the western limb.

AR3293 is a large region with a history of magnetic complexity although it has recently lost a small delta spot and its intermediate spots have largely decayed. AR3296, to the northeast of AR3293, has shown some recent growth although no change in magnetic complexity. A large region AR3297, to the southeast of the other main region, has shown little change over recent hours other than proliferation of some small intermediate spots.

The remaining regions are all smaller, weaker with little or no change over the past few hours. A new region suggested by helio-seismology and weakly apparent on STEREO imagery, may emerge across the east limb through the period.

Moderate activity is expected with M-class flares, and a slight chance of X-class flares. Significant flares are most likely from AR3293, AR3296 and AR3297 in the northeast.

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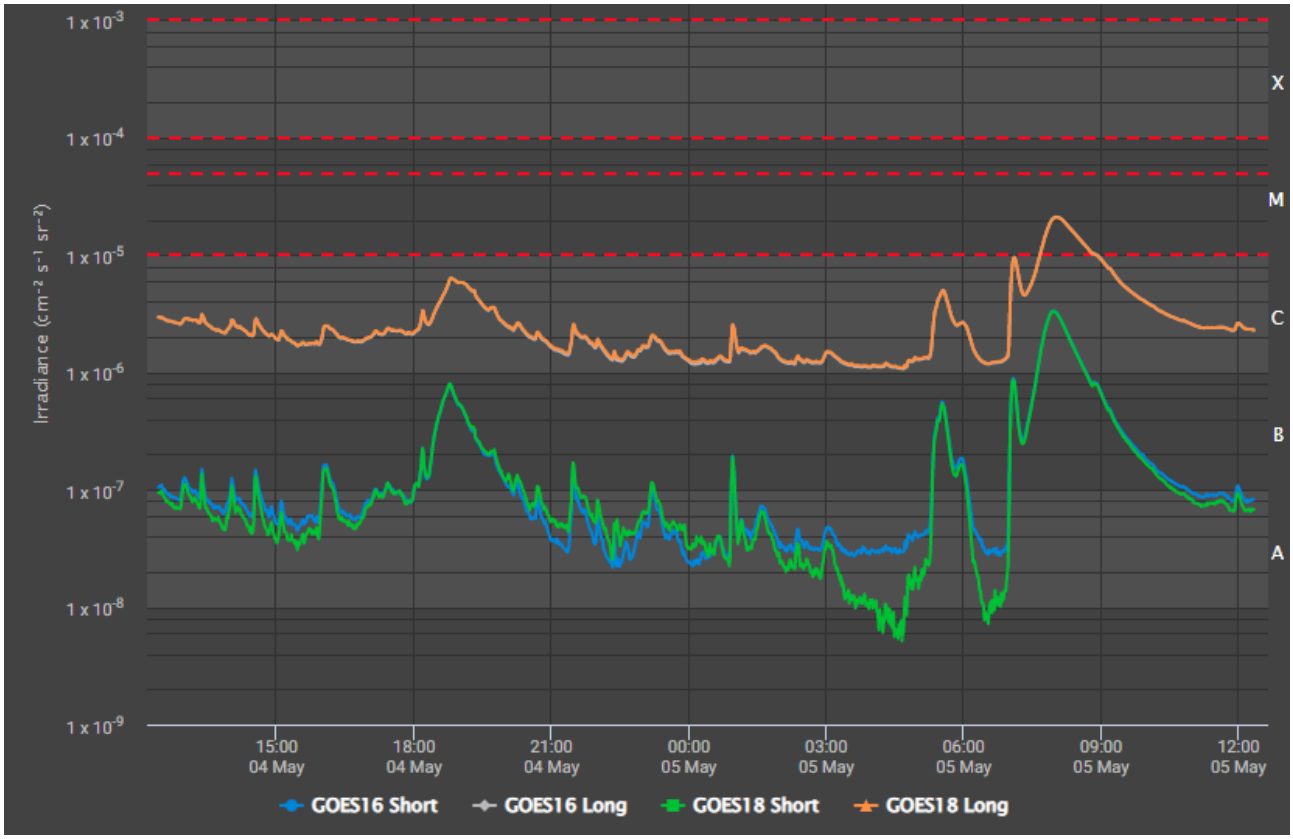
X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: 24-Hour X-Ray trace of GOES-16 and GOES-18.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux as observed by GOES-16 is most likely to persist at background levels. However, count rates may increase with any significant flares that occur, mainly from AR3288 that has just reached the west limb. From Day 2, (6 May) the risk of radiation storms diminishes slightly as AR3288 rotates further beyond the west limb. Other regions in the east present an increasing, but as yet only slight, risk of Earth-directed radiation storms.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	10	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2MeV) electron flux is expected to continue a diurnal oscillation, mainly above the High threshold, but with slightly declining peaks, until any geomagnetic storms occur to distort the radiation belts. Geomagnetic storms are most likely either late Day 3 (7 May) or Day 4 (8 May) associated with the arrival of CMEs. There is a chance that geomagnetic storms associated with the arrival of two HSS from separate coronal hole features may disrupt the radiation belts on Days 2-3 (6-7 May). As a result, high energy electron flux levels are expected to fall to Background or Moderate levels through the period, but with uncertainty in timing.

The corresponding electron fluence is expected to continue above the Active threshold (1e8 integrated flux), but with a slowly declining trend, until late Day 3 or early Day 4, thereafter falling below the Active threshold. The latest MOSWOC REFM model shows this declining trend and is largely accepted, although it appears too quick to fall below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	50	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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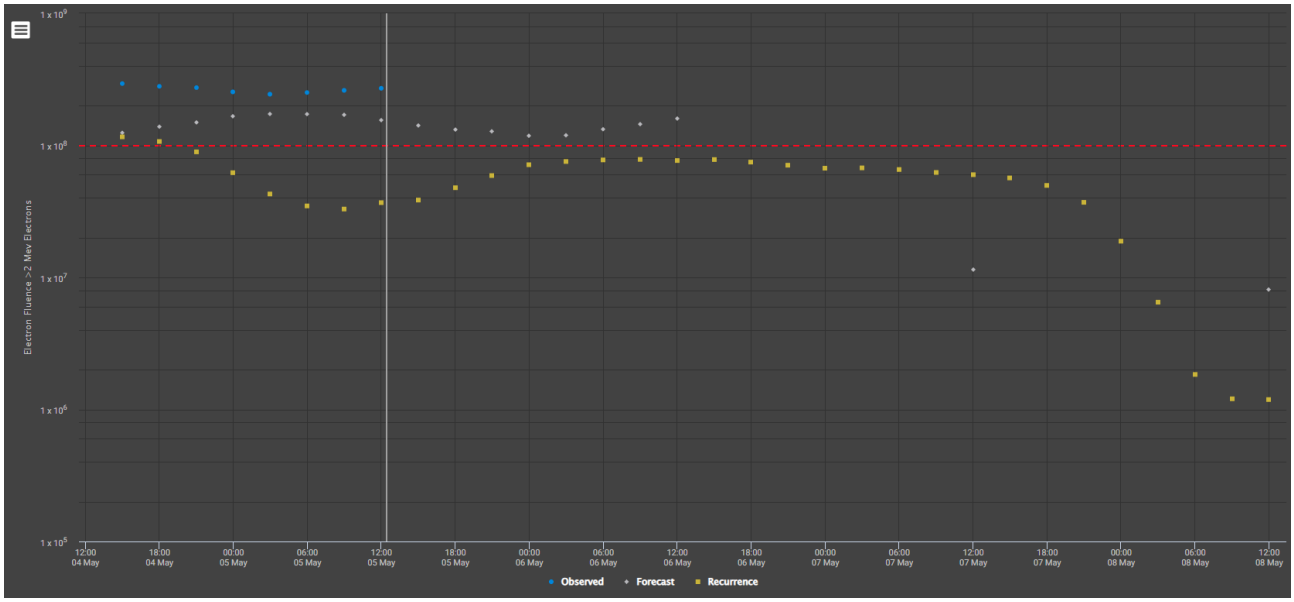
Figure 4: Latest MOSWOC REFM model showing projected decline below High threshold.



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